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# Annotated list of freshwater fishes of the Limoncocha Lagoon, Napo river basin, northern Amazon region of Ecuador

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**Abstract**

An annotated list of the freshwater fishes of the Limoncocha Lagoon, in the Limoncocha Biological Reserve in the northern Amazon region of Ecuador is presented. Fishes were captured between March and July of 2012, and we combined these results with previous studies to provide a comprehensive list of fishes in the Limoncocha Biological Reserve. Thirty-three species belonging to 14 families distributed in 7 orders were collected. The most representative orders in number of species and specimens were Characiformes, Siluriformes, and Perciformes, respectively, being Characiformes as the most important in terms of richness and abundance of species. Characidae (Characiformes) exhibited the greatest abundance and broadest distribution in our samples. A short morphological description and morphometric measurements of each species are also presented.

**Key words**

Limoncocha Biological Reserve, Amazonian basin, Neotropical fauna, Ichthyofauna.

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## Introduction

The diversity of freshwater fishes in the Neotropical region is among the greatest in the world, including 5,160 of the 32,000 valid species of fishes (Nelson et al. 2016) and an undescribed diversity estimated between 8,000 and 9,000 species (Reis et al. 2016). These numbers are almost certainly an underestimate since new species of Neotropical fishes are constantly being described, including from Ecuador (Barriga 2012, Román-Valencia et al. 2013, Escobar et al. 2015, Lujan et al. 2015). Currently, 951 intertidal and continental freshwater species have been identified in Ecuador, most of which occur in the Amazonian region. Although research on the Neotropical fishes of Ecuador is increasing (e.g. Jácome-Negrete and Guarderas 2005, Alverson et al. 2008, Jácome-Negrete 2013, Jiménez-Prado et al. 2015, Aguirre et al. 2016), there is still relatively little known about the distribution of species in many parts of the country. This is of great concern given the increasing threats to aquatic ecosystems throughout the country. Ecuador's northern Amazon region is of particular interest because it is the region most severely impacted by the development of the oil industry. This oil boom brought consequences, such as fragmentation of territories, which has caused an increase pressure on water resources and has changed the ways in which the fish are used (Vallejo 2014). After decades of

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**Table 1.** Average values of the physicochemical parameters from the sampling sites in the Limoncocha Lagoon and its tributaries, Pishira and Playayacu rivers (March and July 2012) (*n* = number of sampled localities per site).

| Physicochemical parameters | Sites | | |
|---|---|---|---|
| | Limoncocha Lagoon (*n* = 14) | Pishira River (*n* = 2) | Playayacu River (*n* = 2) |
| Water temperature (°C) | 26.4 | 23.1 | 11.9 |
| pH | 7.5 | 8.8 | 8.2 |
| Conductivity (µS/cm) | 87.3 | 88.8 | 56.1 |
| Dissolved oxygen (mg/L) | 11.1 | 6.6 | 4.0 |

exploitation, and the increase of other human activities like overfishing, deterioration of aquatic ecosystems is easily noticeable and is aggravated by the lack of policies and regulations related to fishes.

Oil exploitation began in the Limoncocha Biological Reserve (RBL) in 1985, but previous work on the fishes has been limited. Walsh (2003) identified 93 species in 30 families of freshwater fishes. Unfortunately, no species list was provided and the collection sites not specified, making comparisons difficult. Bastidas et al. (2014) collected 20 species in 9 families. Valdiviezo-Rivera et al. (2012), examined the fauna of the lagoon and recorded the presence of 80 species in 33 families based on field collections, photographic records, specimens deposited in the Instituto Nacional de Biodiversidad (INABIO), interviews with fishermen, and surveys of their catches. Herein, we aim to provide an annotated list of the freshwater fishes of the Limoncocha Lagoon, in the RBL, northern Amazon region of Ecuador.

## Methods

**Study site.** We examined the fish fauna in RBL, an important protected area that is within the oil exploration Block No. 15, managed by the state company Petroamazonas.

The RBL is one of the smallest protected areas in Ecuador (4,613.3 ha). It is located in the province of Sucumbíos, Shushufindi canton, Limoncocha parish. It is within the Napo-Pastaza (NP) ichthyo-hydrographic zone. The annual average rain and temperature are 3,065 mm and 24.9 °C respectively. Within the RBL there are 5 types of plant formations: lowland evergreen forest, lowland evergreen forest flooded by white waters, lowland evergreen forest flooded by black waters, lowland floodplain forest (moretal or swamp forest), and lacustrine lowland grassland (Sierra 1999).

The hydrologic system in the RBL is formed by the Pishira and Playayacu rivers and the Limoncocha Lagoon (among other tributaries). The Limoncocha Lagoon has an area of 2.3 km$^2$. Its bottom is composed of mineral sediments such as sand, silt, clay, and a high content of organic matter. Macronutrients are high, and the water is a lemon-greenish color (Valdiviezo-Rivera et al. 2012).

The sampling sites in the Limoncocha Lagoon presents water flow and low to moderate amounts of immersed, emergent, marginal, and floating vegetation. The Pishira River is characterized by a bottom composed of rocks, pebbles, sand, leaves, and small logs; its water is moderately transparent to very clear and slow flowing. There are low to moderate amounts of immersed, emerging, and marginal vegetation. The bottom of the Playayacu River is characterized by mud, sand, leaves, and small to medium-sized logs; water transparency is low to moderate, water flow is moderate, and there is plenty of immersed, emerging, and marginal vegetation. All physochemical parameters were determined during the rainy season, March to July 2012, and site data are listed in Table 1. The average depth of the lagoon was 1.7 m, while the average depths of the Playayacu and Pishira rivers were only 0.4 m and 0.5 m, respectively.

**Data collection.** Fourteen sites were sampled (Table

**Table 2.** Location of sampling sites and sampling methods used to capture fish at the Limoncocha Lagoon and its tributaries, Pishira and Playayacu rivers.

| No. | Site codes | Sites | Geographic coordinates | | Elev. (m) | Sampling methods |
|---|---|---|---|---|---|---|
| | | | Latitude (S) | Longitude (W) | | |
| 1 | LIM-01/LIM-08 | Limoncocha Lagoon: outlet right margin | 00°23'19.98" | 076°35'50.39" | 237 | Gill nets, cast net, baits |
| 2 | LIM-02 | Limoncocha Lagoon: 100 m from entrance of Supaycocha Cabins | 00°22'53.15" | 076°35'36.09" | 232 | Gill nets, cast net, baits |
| 3 | LIM-03 | Limoncocha Lagoon | 00°23'13.33" | 076°36'32.59" | 236 | Gill nets, cast net, baits |
| 4 | LIM-04/LIM-06 | Limoncocha Lagoon: entrance of Supaycocha Cabins | 00°22'57.84" | 076°35'36.51" | 237 | Gill nets, cast net, baits |
| 5 | LIM-05 | Limoncocha Lagoon | 00°23'2.72" | 076°35'39.81" | 236 | Gill nets, cast net, baits |
| 6 | LIM-07 | Limoncocha Lagoon: 100 m from right side of main pier | 00°24'28.14" | 076°37'8.89" | 234 | Gill nets |
| 7 | LIM-09 | Limoncocha Lagoon | 00°23'10.01" | 076°36'23.76" | 238 | Gill nets, cast net, baits |
| 8 | LIM-10/LIM-14 | Pishira River: next to road | 00°21'58.76" | 076°37'41.30" | 250 | Trawl net, baits |
| 9 | LIM-11 | Limoncocha Lagoon | 00°24'0.08" | 076°36'32.83" | 236 | Gill nets |
| 10 | LIM-12/LIM-16 | Playayacu River: entrance from lagoon, 100 m inside jungle | 00°23'30.25" | 076°36'48.54" | 264 | Trawl net, baits |
| 11 | LIM-13 | Limoncocha Lagoon: river outlet | 00°23'18.67" | 076°36'16.55" | 236 | Gill nets |
| 12 | LIM-15 | Limoncocha Lagoon: inlet | 00°23'21.21" | 076°35'49.61" | 236 | Gill nets |
| 13 | LIM-17 | Limoncocha Lagoon | 00°23'39.90" | 076°36'15.46" | 234 | Gill nets, cast net, baits |
| 14 | LIM-18 | Limoncocha Lagoon | 00°23'26.93" | 076°36'34.70" | 234 | Gill nets, cast net, baits |

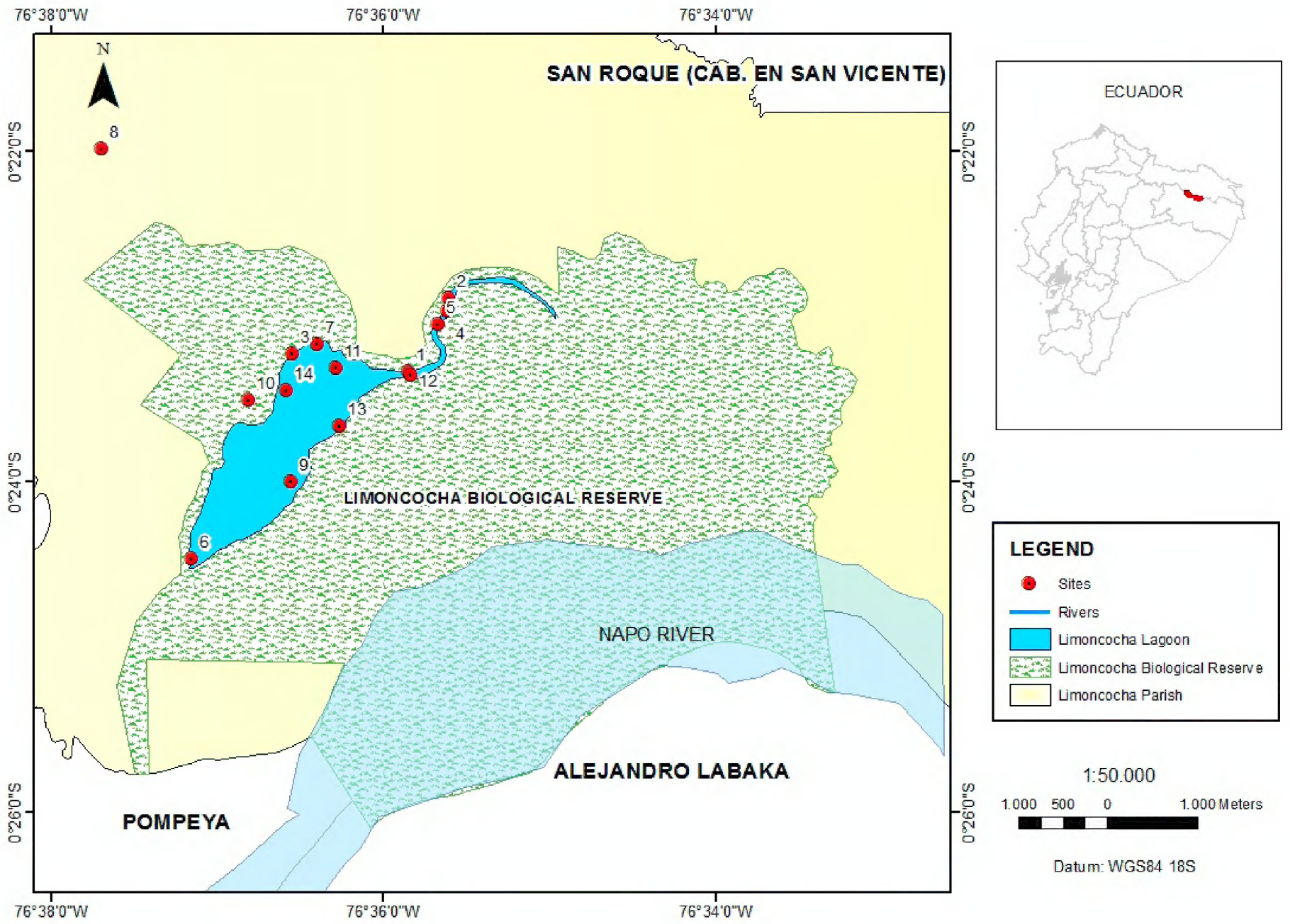


**Figure 1.** Map of study site showing the sampling sites in the Limoncocha Lagoon and its tributaries, Limoncocha Biological Reserve, Napo river basin, Sucumbíos province, Ecuador.

2, Fig. 1): 12 sites in the Limoncocha Lagoon, 1 site in the Pishira River, and 1 site in the Playayacu River. Fishes were captured with trawl net, cast net, gill nets, and baits of different sizes; gill net mesh size ranged between 2.8 cm and 7.5 cm. The specimens were anesthetized in 10% Lidocaine solution. In the field, fishes were fixed in formaldehyde 10%, and subsequently stored in ethanol 75%. We cataloged and deposited 37% of the specimens in the INABIO. Morphometric measurements were taken with an electronic caliper (precision ± 0.02 mm) following Román-Valencia et al. (2005) and Fischer et al. (1995a, 1995b). Morphometric measurements were done 2 times for each parameter. The summary statistics (means, minimum, maximum) for the morphometric measurements were included in Table 3. The coordinates and elevations were recorded with GPS receiver (Garmin Etrex Legend). The classification of species follows Eschmeyer et al. (2017). Finally, we combined our results with those of previous studies to give a comprehensive list of the freshwater fishes present in the RBL that will contribute to the knowledge of the ichthyofauna in this important area and provide data for future conservation measures.

**Data analysis.** Species identifications were performed consulting the taxonomic literature and identification keys (Géry 1977, Kullander 1986, Whitehead et al. 1988, Vari 1984, 1989, 1991, 1992a, 1992b, Vari and Harold 2001, Malabarba 2004, Armbruster and Page 2006, Vanegas-Ríos et al. 2011, Loeb 2012).

A non-parametric jack-knife estimator was used to determine the number of possible species at the study site.

## Results

A total of 264 specimens belonging to 7 orders, 14 families, and 33 species were collected (Table 4). Of the 33 species collected, 26 were present exclusively in the Limoncocha Lagoon, 2 in the Pishira River, and 1 in the Playayacu River (Table 4). One species, *Bujurquina* sp., was common at all 3 locations.

The predominant orders were the Characiformes (21 spp.), Perciformes (5 spp.), and Siluriformes (3 spp.), representing 63.3%, 15.3%, and 9.1%, respectively of

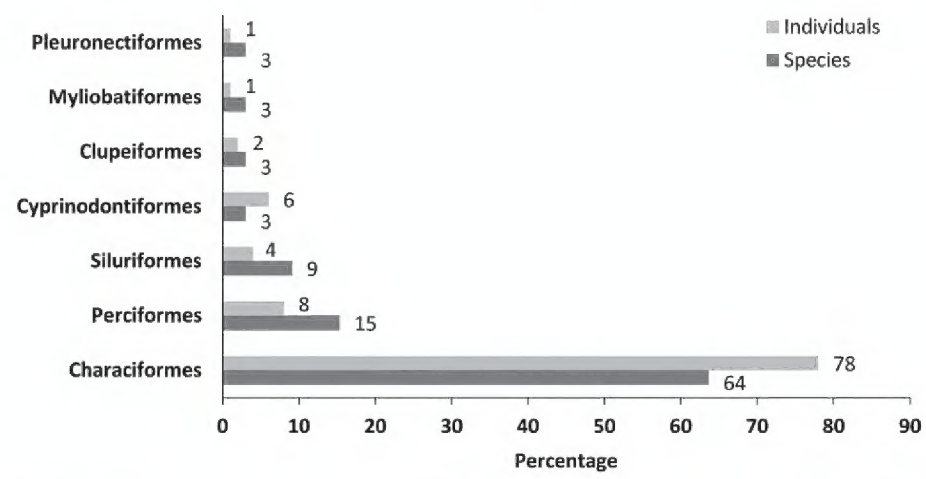


**Figure 2.** Percentage of individuals and species per order at the Limoncocha Lagoon.

**Table 3.** Summary statistics of morphometric measurements. Morphometric measurements (mm) and its respective acronyms: TL = total length, SL = standard length, PL = caudal peduncle length, BD = body depth, OD = orbital diameter, LS = snout length, HL = head length, Weight = weight in alcohol, LOD = lower orbital diameter, LT = tail length, DW = disc width, DL = disc length, PO = pre-oral length, POD = pre-orbital distance.

| | Morphometric measurement (mm) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TL | | SL | | PL | | BD | | OD | | LS | | HL | | Weigth | | LOD | |
| Species | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max |
| **Family Engraulidae** | | | | | | | | | | | | | | | | | | |
| *Anchoviella alleni* | 66.5 | 64.3–68.7 | 50.3 | 49.7–50.9 | 8.4 | 8.2–8.6 | 6.7 | 3.5–10.4 | 5.7 | 5.7–5.8 | 3.6 | 3.3–3.9 | 11.6 | 10.5–12.6 | 1.4 | 1.2–1.5 | — | — |
| **Family Curimatidae** | | | | | | | | | | | | | | | | | | |
| *Curimata aspera* | 125.6 | | 97.4 | | 7.3 | | 29.4 | | 9.5 | | 4.9 | | 25.0 | | 25.5 | | — | — |
| *Curimata vittata* | 166.11 | | 129.4 | | 9.5 | | 48.5 | | 10.4 | | 6.9 | | 33.5 | | 74.9 | | — | — |
| *Potamorhina altamazonica* | 212.2 | 260–186.0 | 162.5 | 140.5–194.8 | 12.6 | 11–15.1 | 61.4 | 50.4–83.3 | 11.5 | 11.1–11.9 | 10.6 | 8.1–14.6 | 50.4 | 41.8–63.8 | 142.5 | 66.7–281.8 | — | — |
| *Steindachnerina bimaculata* | 124.6 | 49.8–166.5 | 98.0 | 35.9–132.1 | 8.4 | 1.7–11.0 | 33.0 | 10.0–45.3 | 7.8 | 3.4–11.3 | 6.4 | 3.7–8.9 | 25.6 | 9.9–36.1 | 36.8 | 1.0–60.4 | — | — |
| **Family Anostomidae** | | | | | | | | | | | | | | | | | | |
| *Leporinus friderici* | 177.9 | 173–182.9 | 141.8 | 140.8–142.7 | 7.4 | 7.3–7.5 | 48.0 | 48–48.1 | 8.8 | 8.8–8.8 | 12.4 | 12.1–12.6 | 37.6 | 37.2–37.9 | 87.5 | 86.7–88.3 | — | — |
| **Family Serrasalmidae** | | | | | | | | | | | | | | | | | | |
| *Pygocentrus nattereri* | 174.0 | 120.1–215.6 | 144.9 | 94.2–180 | 9.4 | 5.2–11.9 | 76.3 | 52.5–91.6 | 9.7 | 7.4–11.6 | 14.1 | 6.4–21.1 | 54.2 | 35.4–71.4 | 161.3 | 38.4–266.9 | — | — |
| *Serrasalmus rhombeus* | 141.6 | | 119.1 | | 10.5 | | 65.1 | | 8.6 | | 9.1 | | 42.7 | | 8.6 | | — | — |
| **Family Characidae** | | | | | | | | | | | | | | | | | | |
| *Aphyocharax* sp. | 39.3 | | 30.0 | | 2.7 | | 9.2 | | 3.1 | | 1.9 | | 8.6 | | 0.5 | | — | — |
| *Astyanax abramis* | 83.0 | 60.1–105.9 | 64.3 | 46.6–82.0 | 3.2 | 2.7–3.7 | 26.1 | 19.8–32.4 | 7.1 | 5.6–8.7 | 4.7 | 3.5–5.9 | 19.8 | 14.1–25.5 | 8.8 | 2.6–14.9 | — | — |
| *Astyanax bimaculatus* | 71.3 | | 53.5 | | 2.9 | | 21.9 | | 5.2 | | 4.5 | | 5.0 | | 4.6 | | — | — |
| *Astyanax henseli* | 47.5 | | 36.8 | | 1.3 | | 16.5 | | 4.2 | | 1.9 | | 10.2 | | 0.9 | | — | — |
| *Bryconamericus* sp. | 63.9 | 40.8–101.9 | 48.2 | 31.4–75.7 | 3.7 | 2.5–4.5 | 18.9 | 11.7–33 | 4.5 | 2.7–8.3 | 2.9 | 1.7–4.5 | 12.9 | 8.1–22.4 | 3.1 | 0.6–13.3 | — | — |
| *Chrysobrycon hesperus* | 37.6 | 21.2–54.9 | 30.4 | 16.2–44.9 | 3.2 | 1.9–4.4 | 11.3 | 5.9–17.1 | 2.4 | 1.7–3.4 | 2.4 | 1.4–3.6 | 7.76 | 4.2–9.8 | 0.5 | 0.1–1.1 | — | — |
| *Creagrutus* sp. | 41.6 | 40.3–43.3 | 31.3 | 30.2–32.2 | 4.0 | 3.5–4.4 | 9.5 | 9.0–10.3 | 3.8 | 3.8–3.9 | 1.6 | 1.3–2.0 | 8.3 | 7.8–9.1 | 0.7 | 0.5–0.9 | — | — |
| *Ctenobrycon hauxwellianus* | 63.7 | 41.2–77.2 | 52.2 | 31.1–61.7 | 3.6 | 3.3–5.4 | 25.8 | 14.8–31.0 | 4.8 | 3.2–6 | 3.0 | 2.0–3.8 | 13.4 | 8.8–15.6 | 19.9 | 0.6–56.0 | — | — |
| *Moenkhausia dichroura* | 76.4 | | 57.8 | | 3.5 | | 21.1 | | 5.3 | | 2.6 | | 14.4 | | 3.7 | | — | — |
| *Moenkhausia oligolepis* | 33.2 | 19.2–45.6 | 24.6 | 14.5–33.7 | 1.5 | 1.0–2.2 | 9.6 | 4–13.0 | 3.4 | 1.6–4.5 | 1.6 | 1.0–2.3 | 7.9 | 4.6–11.0 | 0.4 | 0.1–0.8 | — | — |
| *Roeboides myersii* | 153.4 | 108.7–183.1 | 123.3 | 91–149.6 | 6.1 | 2.8–9.4 | 50.5 | 34.4–60.4 | 9.4 | 7.6–10.8 | 6.9 | 5.4–9.2 | 33.5 | 24.7–41.6 | 45.3 | 12.6–65.2 | — | — |
| *Tetragonopterus argenteus* | 73.7 | 66.5–82.4 | 57.8 | 48.5–65.2 | 3.3 | 2.1–4.8 | 29.2 | 24.8–34.2 | 5.6 | 4.7–6.7 | 2.6 | 1.5–3.5 | 14.4 | 12.5–16.2 | 4.9 | 3.0–6.3 | — | — |
| **Family Triportheidae** | | | | | | | | | | | | | | | | | | |
| *Triportheus elongatus* | 243.6 | | 183.6 | | 13.9 | | 66.2 | | 12.5 | | 14.9 | | 49.2 | | 85.1 | | — | — |
| **Family Crenuchidae** | | | | | | | | | | | | | | | | | | |
| *Characidium* sp. | 72.0 | | 56.3 | | 7.0 | | 13.1 | | 3.7 | | 2.2 | | 13.4 | | 2.4 | | — | — |
| **Family Auchenipteridae** | | | | | | | | | | | | | | | | | | |
| *Trachelyopterus galeatus* | 199.7 | | 160.9 | | 20.3 | | 59.9 | | 4.4 | | 14.5 | | 4.2 | | 167.1 | | — | — |
| **Family Loricariidae** | | | | | | | | | | | | | | | | | | |
| *Pterygoplichtys pardalis* | 343.9 | | 243.8 | | 28.9 | | 51.4 | | 9.4 | | 34.6 | | 61.5 | | 406.5 | | — | — |
| *Pterygoplichtys weberi* | 244.3 | 244.2–244.4 | 129.8 | 87.3–172.4 | 35.6 | 31.0–40.2 | 48.8 | 47.4–50.1 | 7.1 | 6.0–8.3 | 26.3 | 23.8–28.8 | 40.2 | 35.6–44.8 | 156.3 | 153.2–159.3 | — | — |
| **Family Cynolebiidae** | | | | | | | | | | | | | | | | | | |
| *Anablepsoides* cf. *urophthalmus* | 36.2 | 26.3–45.3 | 29.1 | 24.9–34.2 | 5.8 | 4.2–8.5 | 8.8 | 6.9–11.3 | 2.7 | 1.9–3.9 | 2.5 | 2.1–3.7 | 7.7 | 6.2–8.5 | 0.4 | 0.1–0.7 | — | — |
| **Family Sciaenidae** | | | | | | | | | | | | | | | | | | |
| *Plagioscion squamosissimus* | 257.5 | | 208.1 | | 42.3 | | 63.3 | | 14.4 | | 16.4 | | 71.3 | | 186.1 | | — | — |
| **Family Cichlidae** | | | | | | | | | | | | | | | | | | |
| *Aequidens tetramerus* | 38.5 | | 27.3 | | 2.9 | | 12.4 | | 3.8 | | 2.7 | | 10.7 | | 1.0 | | — | — |
| *Astronotus ocellatus* | 231.4 | | 187.3 | | 14.7 | | 89.2 | | 12.8 | | 14.1 | | 59.9 | | 258.7 | | — | — |

**Table 3.** *Continued.*

| | Morphometric measurement (mm) | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | TL | | SL | | PL | | BD | | OD | | LS | | HL | | Weigth | | LOD | |
| Species | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max | mean | min–max |
| *Bujurquina* sp. | 36.8 | 24.5–49.1 | 26.3 | 17.4–35.1 | 2.2 | 1.7–2.7 | 18.5 | 6.9–31.9 | 5.7 | 2.5–8.6 | 4.0 | 2.0–7.6 | 16.0 | 7.5–27 | 6.0 | 0.2–16.2 | — | — |
| *Crenicichla cincta* | 213.8 | | 168.1 | | 16.8 | | 43.6 | | 9.6 | | 17.9 | | 58.3 | | 102.9 | | — | — |
| **Family Achiridae** | | | | | | | | | | | | | | | | | | |
| *Apionichtys menezesi* | 272.9 | | 211.7 | | — | — | 124.4 | | — | — | 18.9 | | 64.6 | | 331.8 | | 2.8 | |

| Species | Morphometric measurement | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LT | | DW | | DL | | PO | | POD | | Weigth | |
| | mean | min-max | mean | min-max | mean | min-max | mean | min-max | mean | min-max | mean | min-max |
| **Family Potamotrygonidae** | | | | | | | | | | | | |
| *Potamotrygon motoro* | 229.5 | | 240.9 | | 209.4 | | 56.5 | | 49.7 | | 779.0 | |

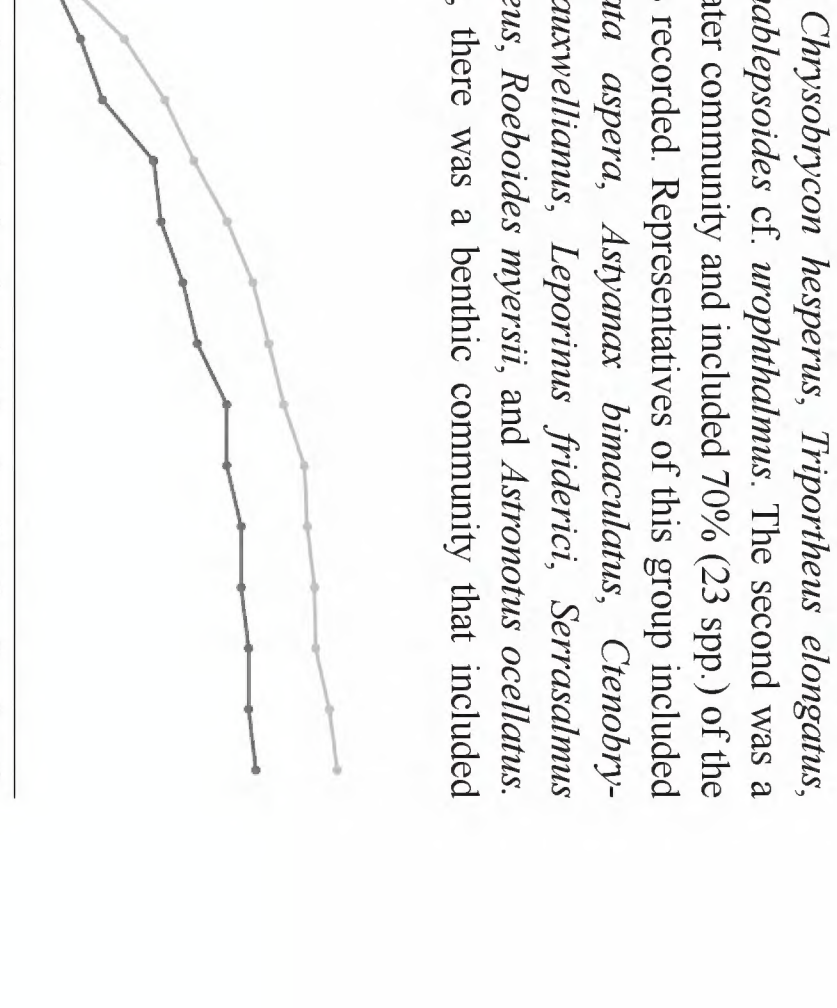


**Figure 3.** Percentage of individuals and species per family sampled at the Limoncocha Lagoon.

the total fish species captured (Fig. 2). The most diverse families were Characidae (36.4%), followed by Curimatidae (12.1%), Cichlidae (12.0%), Serrasalmidae (6.3%), Loricariidae (6.2%), and Cynolebiidae (6.2%). The most abundant species collected were *Moenkhausia oligolepis* (14.4%) and *Tetragonopterus argenteus* (9.3%) (Fig. 3).

The accumulation curve indicated that the observed species richness (33 spp.) represented 75% of the species predicted by the jack-knife estimator (44 spp.) (Fig. 4).

All the collected specimens were small to medium-sized. The majority of captured specimens were small, less than 100 mm total length (TL) but greater than 50 mm TL (18 spp., 54.5%). The species with the largest average standard length (SL) was *Pterygoplichtys pardalis*, 243.8 mm SL, and it was followed by *Plagioscion squamosissimus*, 208.1 mm SL. Three spatially segregated fish communities were distinguished from the lagoon. The first community inhabited the water layer closest to the surface and constituted 12% (4 spp.) of the species recorded. The species in this community were *Anchovi*ella *alleni*, *Chrysobrycon hesperus*, *Triportheus elongatus*, and *Anablepsoides* cf. *urophthalmus*. The second was a mid-water community and included 70% (23 spp.) of the species recorded. Representatives of this group included *Curimata aspera*, *Astyanax bimaculatus*, *Ctenobrycon hauxwellianus*, *Leporinus friderici*, *Serrasalmus rhombeus*, *Roeboides myersii*, and *Astronotus ocellatus*. Finally, there was a benthic community that included




**Figure 4.** Species accumulation curve generated by non-parametric estimator jack-knife 1 based on collections made in the Limoncocha Lagoon, Sucumbíos province, Ecuador.

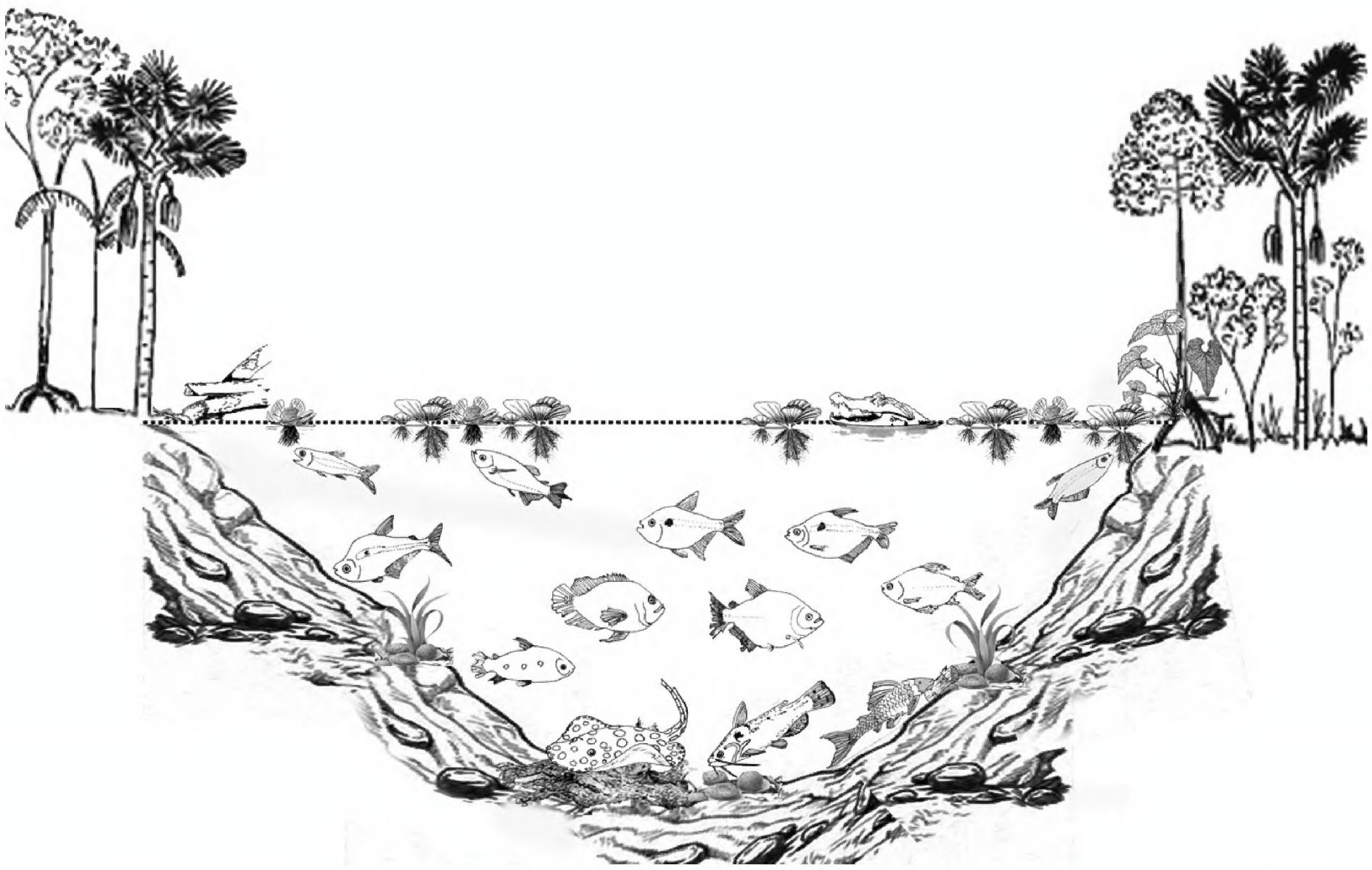

**Figure 5.** Diagram indicating the vertical distribution of representative fish species in the Limoncocha Lagoon. Fish community is distributed in surface, middle and benthic layers of the water. Surface water layer included (from left to right) *Anchoviella alleni*, *Triportheus elongatus* and *Chrysobrycon hesperus*; and middle water layer took in (from left to right) *Roeboides myersii, Leporinus friderici*, *Astronotus ocellatus, Astyanax bimaculatus, Serrasalmus rhombeus, Ctenobrycon hauxwellianus* and *Curimata aspera*. Finally, benthic community included (from left to right) *Potamotrygon motoro*, *Trachelyopterus galeatus* and *Pterygoplichthys pardalis.*

18% (6 spp.) of the species recorded and consisted of *Potamotrygon motoro*, *Characidium* sp., *Pterygoplichthys pardalis*, *Pterygoplichthys weberi*, *Trachelyopterus galeatus*, and *Apionichtys menezesi* (Fig. 5).

## Annotated list of the freshwater fishes of the Limoncocha Lagoon

Order Myliobatiformes
Family Potamotrygonidae

***Potamotrygon motoro*** (Müller & Henle, 1841): Figure 6A

*Taeniura motoro* Müller and Henle 1841: 197–198—Lasso et al. 2013: 209–210.
*Trygon mulleri* Castelnau 1855: 102.
*Potamotrygon circularis* Garman 1913: 419.
*Potamotrygon laticeps* Garman 1913: 417.

**Material examined.** Table 4.

A fish with a disk-shaped body, small head, and long tail with sharp thorns and prickles. Its back is brown to yellowish, with brown or yellow colored ocelli, edged with black. The average length of the specimens captured in the lagoon is 35 cm TL (Valdiviezo-Rivera et al. 2012). This fish has commercial value in aquariums; local people catch them for their own consumption and in many cases the fishes are even returned to the lagoon (Valdiviezo-Rivera et al. 2012).

Order Clupeiformes
Family Engraulidae

***Anchoviella alleni*** (Myers, 1940): Figure 6B

*Amplova alleni* Myers 1940: 441—Whitehead et al. 1988: 324–325.
*Anchoviella alleni*—Loeb 2012: 16–17.

**Material examined.** Table 4.

This is a small fish with silvery hues, and an elongated and slightly compressed body. This species is recognized by its moderately long snout, short maxilla (Whitehead et al. 1988), and upper jaw with its posterior margin extending beyond the posterior margin of the pupil (Loeb 2012).

Order Characiformes
Family Curimatidae

***Curimata aspera*** (Günther, 1868): Figure 6C

*Curimatus asper* Günther 1868: 478–479—Géry 1977: 230; Vari 1989: 50–54.
*Curimatus simulatus* Eigenmann and Eigenmann 1889: 430.

**Material examined.** Table 4.

This is a silver-colored species that lacks teeth in its jaws. It is medium-sized, reaching 20 cm TL (Valdiviezo-Rivera et al. 2012). It usually swims in large groups and is especially abundant near the bottom and along the banks of the lagoon. It displays migratory habits. It feeds

**Figure 6.** Representative freshwater fishes of the Limoncocha Lagoon, Napo river basin. **A.** *Potamotrygon motoro* (photograph by Santiago Calero). **B.** *Anchoviella alleni* (photograph by Santiago Calero). **C.** *Curimata aspera* (photograph by Cecilia Puertas). **D.** *Curimata vittata* (photograph by Jonathan Valdiviezo-Rivera). **E.** *Potamorhina altamazonica* (photograph by Santiago Calero). **F.** *Steindachnerina bimaculata* (photograph by Carolina Carrillo-Moreno). **G.** *Leporinus friderici* (photograph by Santiago Calero). **H.** *Pygocentrus nattereri* (photograph by Santiago Calero).

**Table 4.** Annotated list of the freshwater fishes of Limoncocha and their respective capture sites L = Limoncocha Lagoon, PI = Pishira River, PL = Playayacu River.

| Species | Sites L | PI | PL | Voucher material (no. of specimens) |
|---|---|---|---|---|
| **Myliobatiformes** | | | | |
| **Potamotrygonidae** | | | | |
| *Potamotrygon motoro* | X | | | MECN-DP: 2462 (1) |
| **Clupeiformes** | | | | |
| **Engraulidae** | | | | |
| *Anchoviella alleni* | X | | | MECN-DP: 2466 (2) |
| **Characiformes** | | | | |
| **Curimatidae** | | | | |
| *Curimata aspera* | X | | | MECN-DP: 2291 (1) |
| *Curimata vittata* | X | | | MECN-DP: 2311 (1) |
| *Potamorhina altamazonica* | X | | | MECN-DP: 2280 (2) |
| | | | | MECN-DP: 2317 (1) |
| *Steindachnerina bimaculata* | X | | | MECN-DP: 2315 (1) |
| | | | | MECN-DP: 2318 (1) |
| | | | | MECN-DP: 2467 (1) |
| | | | | MECN-DP: 2468 (1) |
| **Anostomidae** | | | | |
| *Leporinus friderici* | X | | | MECN-DP: 2309 (2) |
| **Serrasalmidae** | | | | |
| *Pygocentrus nattereri* | X | | | MECN-DP: 2294 (1) |
| | | | | MECN-DP: 2313 (1) |
| | | | | MECN-DP: 2464 (1) |
| *Serrasalmus rhombeus* | X | | X | MECN-DP: 2293 (1) |
| **Characidae** | | | | |
| *Aphyocharax* sp. | X | | | MECN-DP: 2470 (1) |
| *Astyanax abramis* | X | | X | MECN-DP: 2471 (1) |
| | | | | MECN-DP: 2475 (1) |
| *Astyanax bimaculatus* | X | | | MECN-DP: 2282 (1) |
| *Astyanax henseli* | X | | | MECN-DP: 2286 (1) |
| *Bryconamericus* sp. | | X | X | MECN-DP: 2314 (1) |
| | | | | MECN-DP: 2477 (7) |
| *Chrysobrycon hesperus* | | X | X | MECN-DP: 2476 ( 4) |
| | | | | MECN-DP: 2483 (2) |
| *Creagrutus* sp. | | X | | MECN-DP: 2479 (3) |
| *Ctenobrycon hauxwellianus* | X | | | MECN-DP: 2279 (2) |
| | | | | MECN-DP: 2284 (2) |
| | | | | MECN-DP: 2472 (2) |
| *Moenkhausia dichroura* | X | | | MECN-DP: 2283 (1) |
| *Moenkhausia oligolepis* | | X | | MECN-DP: 2319 (1) |
| | | | | MECN-DP: 2480 (5) |
| | | | | MECN-DP: 2481 (5) |
| | | | | MECN-DP: 2482 (3) |
| *Roeboides myersii* | X | | | MECN-DP: 2278 (1) |
| | | | | MECN-DP: 2287 (1) |
| | | | | MECN-DP: 2312 (4) |
| | | | | MECN-DP: 2465 (1) |
| *Tetragonopterus argenteus* | X | | | MECN-DP: 2295 (1) |
| | | | | MECN-DP: 2469 (2) |
| | | | | MECN-DP: 2583 (3) |
| | | | | MECN-DP: 2584 (3) |
| **Triportheidae** | | | | |
| *Triportheus elongatus* | X | | | MECN-DP: 2310 (1) |
| **Crenuchidae** | | | | |
| *Characidium* sp. | | | X | MECN-DP: 2474 (1) |
| **Siluriformes** | | | | |
| **Auchenipteridae** | | | | |
| *Trachelyopterus galeatus* | X | | | MECN-DP: 2281 (1) |
| **Loricariidae** | | | | |
| *Pterygoplichtys pardalis* | X | | | MECN-DP: 2290 (1) |
| *Pterygoplichtys weberi* | X | | | MECN-DP: 467 (2) |
| **Cyprinodontiformes** | | | | |
| **Cynolebiidae** | | | | |
| *Anablepsoides* cf. *urophthalmus* | X | | | MECN-DP: 2297 (3) |
| | | | | MECN-DP: 2484 (3) |
| **Perciformes** | | | | |
| **Sciaenidae** | | | | |
| *Plagioscion squamosissimus* | X | | | MECN-DP: 2289 (1) |
| **Cichlidae** | | | | |
| *Aequidens tetramerus* | X | | | MECN-DP: 2296 (1) |
| *Astronotus ocellatus* | X | | | MECN-DP: 2288 (1) |
| *Bujurquina* sp. | X | X | X | MECN-DP: 2285 (1) |
| | | | | MECN-DP: 2473 (1) |
| | | | | MECN-DP: 2478 (1) |
| *Crenicichla cincta* | X | | X | MECN-DP: 2308 (1) |
| **Pleuronectiformes** | | | | |
| **Achiridae** | | | | |
| *Apionichtys menezesi* | X | | | MECN-DP: 2463 (1) |

on bottom-dwelling microorganisms. This fish are highly prized as food and has a high commercial potential. Very little is known about the natural history of this species.

***Curimata vittata*** (Kner, 1858): Figure 6D

*Curimatus vittatus* Kner 1858a: 76—Géry 1977: 230-232; Vari 1989: 27–30.

*Curimata murieli* Allen in Eigenmann and Allen 1942: 298–299.

**Material examined.** Table 4.

This is a silver-colored species that lacks teeth in its jaws. It can be easily recognized from other Curimatidae by its black transverse bands on the back of its body. This species usually travels in large groups and has migratory habits (Vari 1989). These fish are highly prized as a food and have a high ornamental potential (Valdiviezo-Rivera et al. 2012). Very little is known about their natural history.

***Potamorhina altamazonica*** (Cope, 1878): Figure 6E

*Curimatus altamazonicus* Cope 1878: 684—Vari 1984: 19–23.

**Material examined.** Table 4.

This is a medium-sized fish with a moderately elongate and robust body, silver color, and with small scales and transparent fins. The mouth is toothless. This species migrates for breeding purposes (Carvalho de Lima and Araújo-Lima 2004) and feeds on algae and organic detritus from the bottom. This is one of the most important food fishes for local villagers (Valdiviezo-Rivera et al. 2012).

***Steindachnerina bimaculata*** (Steindachner, 1876): Figure 6F

*Curimatus bimaculatus* Steindachner 1876: 76—Vari 1991: 29–30; Galvis et al. 2006: 159–160.

*Curimatus trachystethus* Cope 1878: 684.

*Curimata melaniris* Fowler 1940: 253.

**Material examined.** Table 4.

This body of this species is somewhat compressed and silvery with a dark longitudinal, somewhat diffuse lateral band. Their color pattern consists of small irregularly shaped dark spots on the back of the body, a most noticeable feature of adults of this species (Vari 1991). It has a small toothless mouth. This fish have high commercial value for the aquarium trade. This species is not of major importance in subsistence fishing (Valdiviezo-Rivera et al. 2012).

Family Anostomidae

***Leporinus friderici*** (Bloch, 1794): Figure 6G
*Salmo friderici* Bloch 1794: 94—Géry 1977: 163; Galvis et al. 2006: 130.

**Material examined.** Table 4.

This medium-sized species has a robust body with a color pattern consisting of 3 dark oval spots on the midline of the body and a series of less intense vertical bands in the dorsal region. During the breeding season these fish migrate to headwaters to spawn. This species has commercial significance; adult specimens are used for human consumption and juveniles are used as ornamentals (Valdiviezo-Rivera et al. 2012).

Family Serrasalmidae

***Pygocentrus nattereri*** Kner, 1858: Figure 6H
*Pygocentrus nattereri* Kner 1858b: 166—Galvis et al. 2006: 173–174.
*Pygocentrus altus* Gill 1870: 93.

**Material examined.** Table 4.

The body of this species is rhomboid in shape and laterally compressed, with a very robust head. It is dark silver when adult. The jaws are prominent and with strong, sharp teeth. These fish have an excellent olphatory sense (Ghosh and Chakrabarti 2016). They are carnivores and scavengers. They are caught in subsistence fishing.

***Serrasalmus rhombeus*** (Linnaeus, 1766): Figure 7A
*Salmo rhombeus* Linnaeus 1766: 514—Galvis et al. 2006: 177–178.
*Serrasalmo immaculatus* Cope 1878: 692.
*Serrasalmo boekeri* Ahl 1931: 406.

**Material examined.** Table 4.

This species has a rhomboid-shaped body and an intensely silver color with small rounded dark spots. They have large, sharp teeth, which are used by several Amazonian communities as arrowheads and as scissors to cut hair and meat. These fish feed on scales, aquatic insects, crustaceans, and other smaller fish, but they also eat cyperacean seeds (Machado-Allison and Garcia 1986). Piranhas are prized as food by local people; they have commercial and ornamental value (Valdiviezo-Rivera et al. 2012).

Family Characidae

***Aphyocharax*** **sp.**: Figure 7B

**Material examined.** Table 4.

This is a small, elongate, silver-colored species with a deep red caudal fin and the remaining fins yellow; there is a somewhat diffuse longitudinal band, which extends from the eye to the median caudal-fin rays (Galvis et al. 2006). This species has an adipose fin and incomplete lateral line. The dorsal fin is located in the posterior half of its body. These fish have no commercial value but have great potential as ornamental fish due to their striking coloration.

***Astyanax abramis*** (Jenyns, 1842): Figure 7C
*Tetragonopterus abramis* Jenyns 1842: 123—Géry 1977: 409, 427.

**Material examined.** Table 4.

This species has a deep, compressed body, and silver coloration, with an oval black spot behind the head and another spot at the base of the caudal fin, which continues to the end of it. Small individuals tend to be omnivorous, preferring plant material and insects, while larger fish are carnivores, preferring microcrustaceans and insects (Barros 2004).

***Astyanax bimaculatus*** (Linnaeus, 1758): Figure 7D
*Salmo bimaculatus* Linnaeus 1758: 311—Géry 1977: 426-430.
*Tetragonopterus bartlettii* Günther 1866: 30.
*Astyanax bimaculatus borealis* Eigenmann 1908: 96.
*Astyanax bimaculatus incaicus* Tortonese 1942: 62.

**Material examined.** Table 4.

This species has a compressed body, silver color, and an oval humeral spot. It is a migratory species that lives in rivers, streams, and lakes. It has ornamental value for its color, peaceful disposition, and gregarious behavior (Valdiviezo-Rivera et al. 2012).

***Astyanax henseli*** de Melo & Buckup, 2006: Figure 7E
*Astyanax henseli* de Melo and Buckup 2006: 46–48.
*Tetragonopterus aeneus* Hensel 1870: 87–88.

**Material examined.** Table 4.

The body is dark silver colored dorsally; there is a well-marked black spot on the caudal fin and extending over the central rays, as well as 2 vertically elongated humeral spots. The maxilla has 2–5 teeth in the anterior side (de Melo and Buckup 2006). Very little is known of its natural history.

***Bryconamericus*** **sp.**: Figure 7F

**Material examined.** Table 4.

This species has large scales and a silver-colored body, with a dark longitudinal band that increases in intensity towards to the base of the caudal-fin. The base of the caudal fin lacks scales. The lateral line is complete. The maxilla has 4 teeth. This is one of the most common species in the lagoon (Valdiviezo-Rivera et al. 2012). It feeds on aquatic invertebrates (benthos) and terrestrial invertebrates, like ants, wasps and bees, that fall into the water. The natural history of this species is still unknown and nothing can be said about its taxonomy.

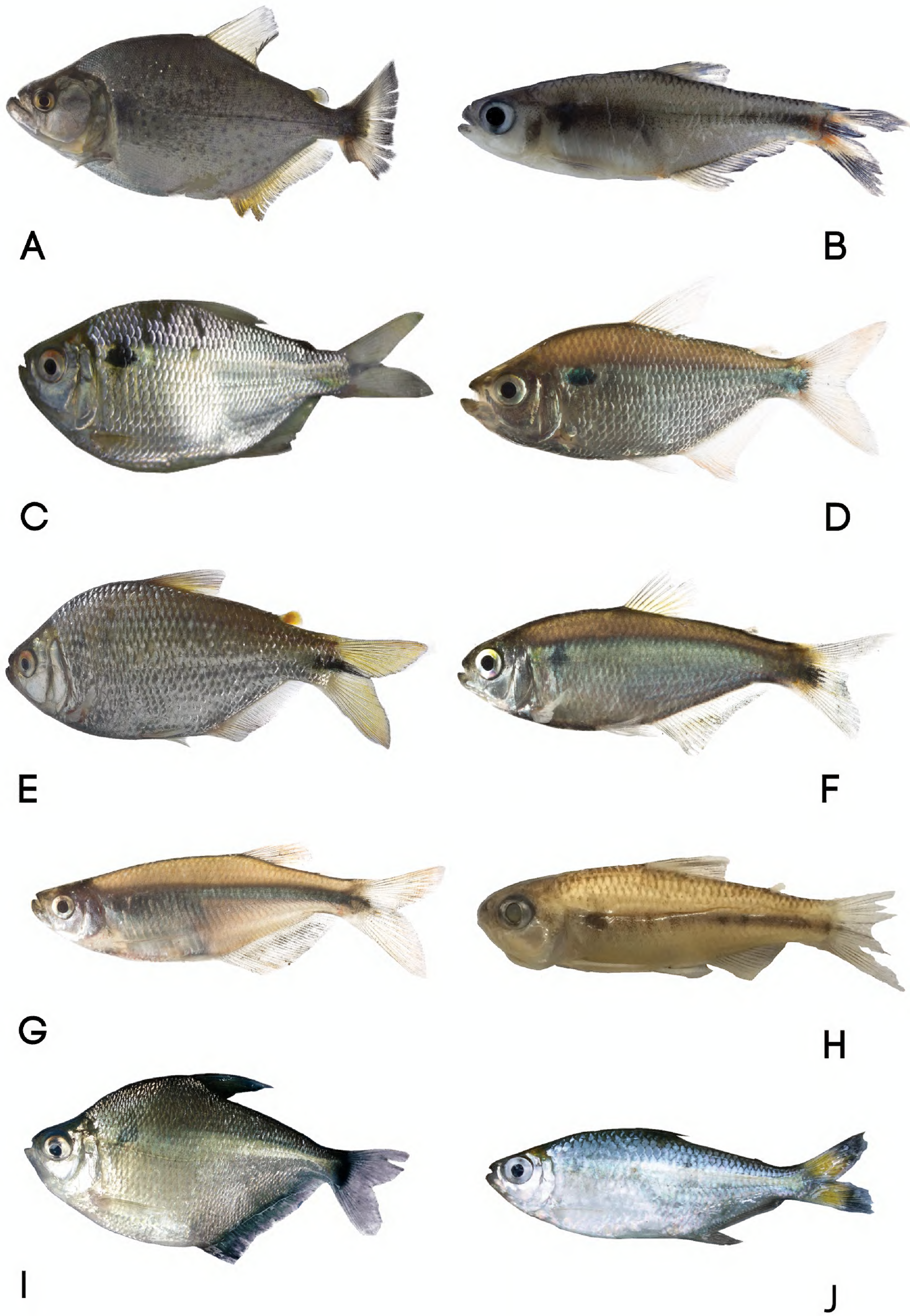


**Figure 7.** Representative freshwater fishes of the Limoncocha Lagoon, Napo river basin. **A.** *Serrasalmus rhombeus* (photograph by Santiago Calero). **B.** *Aphyocharax* sp. (photograph by Carolina Carrillo-Moreno). **C.** *Astyanax abramis* (photograph by Jonathan Valdiviezo-Rivera). **D.** *Astyanax bimaculatus* (photograph by Santiago Calero). **E.** *Astyanax henseli* (photograph by Santiago Calero). **F.** *Bryconamericus* sp. (photograph by Santiago Calero). **G.** *Chrysobrycon hesperus* (photograph by Santiago Calero). **H.** *Creagrutus* sp. (photograph by Jonathan Valdiviezo-Rivera). **I.** *Ctenobrycon hauxwellianus* (photograph by Cecilia Puertas). **J.** *Moenkhausia dichroura* (photograph by Jonathan Valdiviezo-Rivera).

***Chrysobrycon hesperus*** (Böhlke, 1958): Figure 7G

*Hysteronotus hesperus* Böhlke 1958: 35—Géry 1977: 351–358.

**Material examined.** Table 4.

This species has an elongated and laterally compressed body with a straight dorsal profile. It is a small species, maximum SL to 8.18 cm (Reis et al. 2003). This species is not very abundant in catches since individuals prefer to stay along the margins among submerged vegetation; they are usually found in areas with moderate current. This species is known to feed on insect larvae, but otherwise, very little is known about its natural history. *Chrysobrycon* spp. present 3–16 teeth in the maxilla, except for *Chrysobrycon guahibo*. In contrast, *Gephyrocharax* has fewer than 6 teeth in the maxilla (Géry 1977, Vanegas-Ríos et al. 2011, Vanegas-Ríos and Urbano-Bonilla 2017).

***Ctenobrycon hauxwellianus*** (Cope, 1870): Figure 7I

*Tetragonopterus hauxwellianus* Cope 1870: 560—Géry 1977: 431–432, Galvis et al. (2006): 198.

*Ctenobrycon rhabdops* Fowler 1913: 537.

**Material examined.** Table 4.

This silver-colored species has a deep, diamond-shaped, laterally compressed body. It inhabits along the banks of rivers with moderate current and a sandy-muddy bottom. It occupies the middle zone of the water column, where it swims upstream on the central canal in schools of 15 or more individuals; overnight it retreats in marginal areas with reduced water flow (Galvis et al. 2006). It has potential as an ornamental fish.

***Creagrutus* sp.**: Figure 7H

**Material examined.** Table 4.

This is a small undescribed species, which belongs to the genus *Creagrutus*, one of the most diverse genera of Neotropical characins (Harold and Vari 1994). Distinctive features of this genus include the presence of 3 rows of teeth in the premaxilla and a short jaw (Bölhke and Saul 1975 cited by Román-Valencia and Cala 1997). The anal fin has up to 16 rays. This species has no substantial importance for subsistence or commercial fishing (Valdiviezo-Rivera et al. 2012).

***Moenkhausia dichroura*** (Kner, 1858): Figure 7J

*Tetragonopterus dichourus* Kner 1858a: 80—Géry 1977: 438–442, Galvis et al. 2006: 218.

**Material examined.** Table 4.

This species has an elongated, silver body, with fins having yellow hues. It is recognized by the silvery line that runs the length of the body from the operculum to the base of the caudal fin. The lobes of the caudal fin have a black band, which do not cover the extremes. It is unimportant in commercial and subsistence fishing due to their small size (Valdiviezo-Rivera et al. 2012). However, this species is used as fishing bait (Valdiviezo-Rivera et al. 2012). It has ornamental potential due to the striking coloration.

***Moenkhausia oligolepis*** (Günther, 1864): Figure 8A

*Tetragonopterus oligolepis* Günther 1864: 327—Géry 1977: 438–443, Galvis et al. 2006: 222.

**Material examined.** Table 4.

This is a silver-colored fish; its body is somewhat elongate and compressed. It is recognized by its blood-red upper iris. There is also a black band around the caudal fin from the base to about half the length of the fin. This species has omnivorous habits; it feeds on worms, insects, crustaceans and plant material. This species is an important part of the diet of many birds and other fish. These fish are used as bait (Valdiviezo-Rivera et al. 2012), and they are highly valued as ornamental fish, due to their striking coloration and gregarious behavior.

***Roeboides myersii*** Gill, 1870: Figure 8B

*Raeboides myersii* Gill 1870: 92—Géry 1977: 315–318, Galvis et al. 2006: 229.

*Roeboides rubrivertex* Cope 1872: 265.

*Charax hasemani* Steindachner 1915: 348.

**Material examined.** Table 4.

This silver-colored fish has a compressed body. The head is pointed and flattened. On the outer part of the upper jaw, there are teeth projecting outward with which they use to feed on the scales of other fish (Galvis et al. 2006). This species inhabit low-current water, where it swims in schools. It is caught, mostly incidentally, by subsistence fishing (Valdiviezo-Rivera et al. 2012).

***Tetragonopterus argenteus*** Cuvier, 1816: Figure 8C

*Tetragonopterus argenteus* Cuvier 1816: 166—Géry 1977: 450–451, Galvis et al. 2006: 233–234.

**Material examined.** Table 4.

This silver-colored species has a compressed, disc-shaped body. There are 2 vertically elongated humeral spots. In shape, this species is similar to *Ctenobrycon hauxwellianus* and *Gymnocorymbus thayeri* (Galvis et al. 2006), found previously in RBL (Valdiviezo-Rivera et al. 2012), but it differs by its larger eyes and scales and their stepped lateral line (Galvis et al. 2006). This species feeds on plant material such as seeds and fruits. It is a valued ornamental fish, and it is also used as fishing bait (Valdiviezo-Rivera et al. 2012).

Family Triportheidae

***Triportheus elongatus*** (Günther, 1864): Figure 8D

*Chalcinus elongatus* Günther 1864: 342—Géry 1977: 342–343; Galvis et al. 2006: 236–237.

*Chalcinus elongatus iquitensis* Nakashima 1941: 63.

*Chalcinus amazonensis* Miranda Ribeiro 1941: 174.

*Chalcinus cruzi* Miranda Ribeiro 1941: 173.

**Material examined.** Table 4.

The body of this medium-sized species is elongate, compressed and with ventral keel. Although this fish does not represent a large percentage of the fish consumed by locals, they are highly valued for their special flavor, which is thought to result from their omnivorous diet (Goulding et al. 2003).

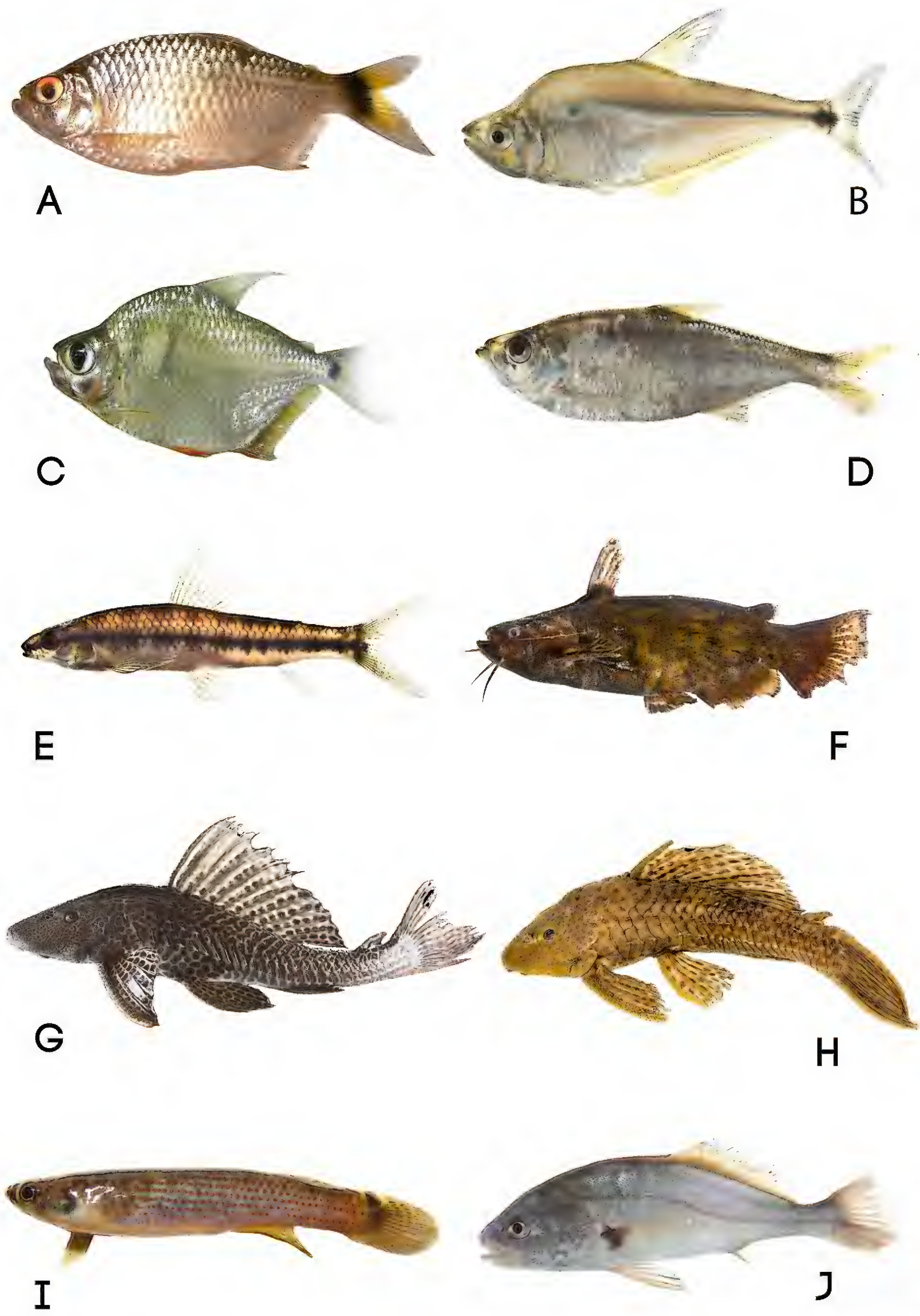


**Figure 8.** Representative freshwater fishes of the Limoncocha Lagoon, Napo river basin. **A.** *Moenkhausia oligolepis* (photograph by Jonathan Valdiviezo-Rivera). **B.** *Roeboides myersii* (photograph by Santiago Calero). **C.** *Tetragonopterus argenteus* (photograph by Jonathan Valdiviezo-Rivera). **D.** *Triportheus elongatus* (photograph by Santiago Calero). **E.** *Characidium* sp. (photograph by Santiago Calero). **F.** *Trachelyopterus galeatus* (photograph by Santiago Calero). **G.** *Pterygoplichthys pardalis* (photograph by Santiago Calero). **H.** *Pterygoplichthys weberi* (photograph by Santiago Calero). **I.** *Anablepsoides* cf. *urophthalmus* (photograph by Jonathan Valdiviezo-Rivera). **J.** *Plagioscion squamosissimus* (photograph by Santiago Calero).

Family Crenuchidae

***Characidium* sp.**: Figure 8E

**Material examined.** Table 4.

This species has an elongated body. It is light brown with a dark stripe extending from the snout to the base of the caudal-fin; there are 9 transverse bands along its body. There are 2 or more unbranched rays in the mesial portion of the pectoral fin. The lower jaw presents a row of prominent teeth and a second row with much smaller teeth (Maldonado-Ocampo et al. 2005). It lives in both fast-flowing and still water. It is valued as an ornamental fish.

Order Siluriformes
Family Auchenipteridae

***Trachelyopterus galeatus*** (Linnaeus, 1766): Figure 8F
*Silurus galeatus* Linnaeus 1766: 503–504—Galvis et al. 2006: 275–276.

**Material examined.** Table 4.

This species has an elongate, robust brown body, with irregular dark brown blotches. It feeds on small fish, worms, insects, and sometimes fruit (Le Bail et al. 2000). This fish is highly valued for food in subsistence fishing but is not important at commercial fishery (Valdiviezo-Rivera et al. 2012).

Family Loricariidae

***Pterygoplichthys pardalis*** (Castelnau, 1855): Figure 8G
*Hypostomus pardalis* Castelnau 1855: 42—Burgess 1989: 714–747, Galvis et al. 2006: 347–348.
*Liposarcus varius* Cope 1872: 284.
*Liposarcus jeanesianus* Cope 1874: 135.

**Material examined.** Table 4.

Adults of this species present a geometric pattern of light lines on head and lateral spots coalescing to form chevrons that outline the posterior border of the lateral plates; these are mostly discrete spots on the venter and chevrons on the caudal peduncle (Armbruster and Page 2006). The buccal papilla is a single, tongue-shaped structure (Armbruster and Page 2006). The dorsal fin usually bears a strong spine and 11 rays (Armbruster and Page 2006). This benthic, nocturnal species feeds on detritus and periphyton attached to submerged logs and aquatic macrophytes. While it can be found in rivers with current, it prefers backwater areas. It is valued as food but also has commercial value as an ornamental fish (Valdiviezo-Rivera et al. 2012).

***Pterygoplichthys weberi*** Armbruster & Page, 2006: Figure 8H
*Pterygoplichthys weberi* Armbruster and Page 2006: 406.

**Material examined.** Table 4.

The buccal papilla is shallowly divided; the dorsal fin usually has a strong spine and 11 rays; and keels are present on all plate rows. The lateral keel odontodes are almost perpendicular to the plates, and in adults, the longest keel odontodes are longer than the lateral line plates (Armbruster and Page 2006). This species, which lives in stream bottoms, mainly feeds on algae and detritus. It has a great importance in subsistence fishing and are highly prized as ornamental fish for their striking color pattern (Valdiviezo-Rivera et al. 2012).

Order Cyprinodontiformes
Family Cynolebiidae

***Anablepsoides* cf. *urophthalmus***: Figure 8I

**Material examined.** Table 4.

This is a small, distinct species with a subcylindrical, elongate body; the caudal fin is rounded. It is very tolerant of adverse environmental conditions such as poor water quality and changes in salinity and temperature (Valdiviezo-Rivera et al. 2012). It is highly valued as an aquarium fish.

Order Perciformes
Family Sciaenidae

***Plagioscion squamosissimus*** (Heckel, 1840): Figure 8J
*Sciaena squamosissima* Heckel 1840: 438—Galvis et al. 2006: 390.
*Plagioscion squamosissimus iquitensis* Nakashima 1941: 68.

**Material examined.** Table 4.

This species has an elongate body, an intensely silvery color, and dark spots on all fins. The mouth is terminal and oblique in lateral view (Casatti 2005). The teeth are conical, externally visible in many specimens; the teeth in the inner series of premaxilla are large and conical (Casatti 2005). Scales ctenoid, except for cycloid scales on snout, preopercle, lachrymal, and second to fourth infraorbitals. There are large scales along the lateral line covered by smaller scales. The caudal fin is almost completely covered by scales (Casatti 2005). There are elongate gill rakers on first gill arch (Casatti 2005). When out of water this species can produce noises using its swim bladder. It is valued for human consumption, given the excellent quality of the meat. Despite its commercial importance and potential for fish farming, little is known about its natural history.

Family Cichlidae

***Aequidens tetramerus*** (Heckel, 1840): Figure 9A
*Acara tetramerus* Heckel 1840: 341—Kullander 1986: 339–347, Galvis et al. 2006: 393.
*Chromys uniocellata* Castelnau 1855: 15.
*Acaronia trimaculata* Allen in Eigenmann and Allen 1942: 389.

**Material examined.** Table 4.

This species has an oval body that varies in color depending on the habitat. It shows 2 oval spots: 1 at the middle of its body and other at the base of the caudal fin. It feeds on insects but also fish and algae (Galvis et al. 2006). This species is valued as an ornamental fish due to its bright colors and its ease of reproduction in captivity. It is

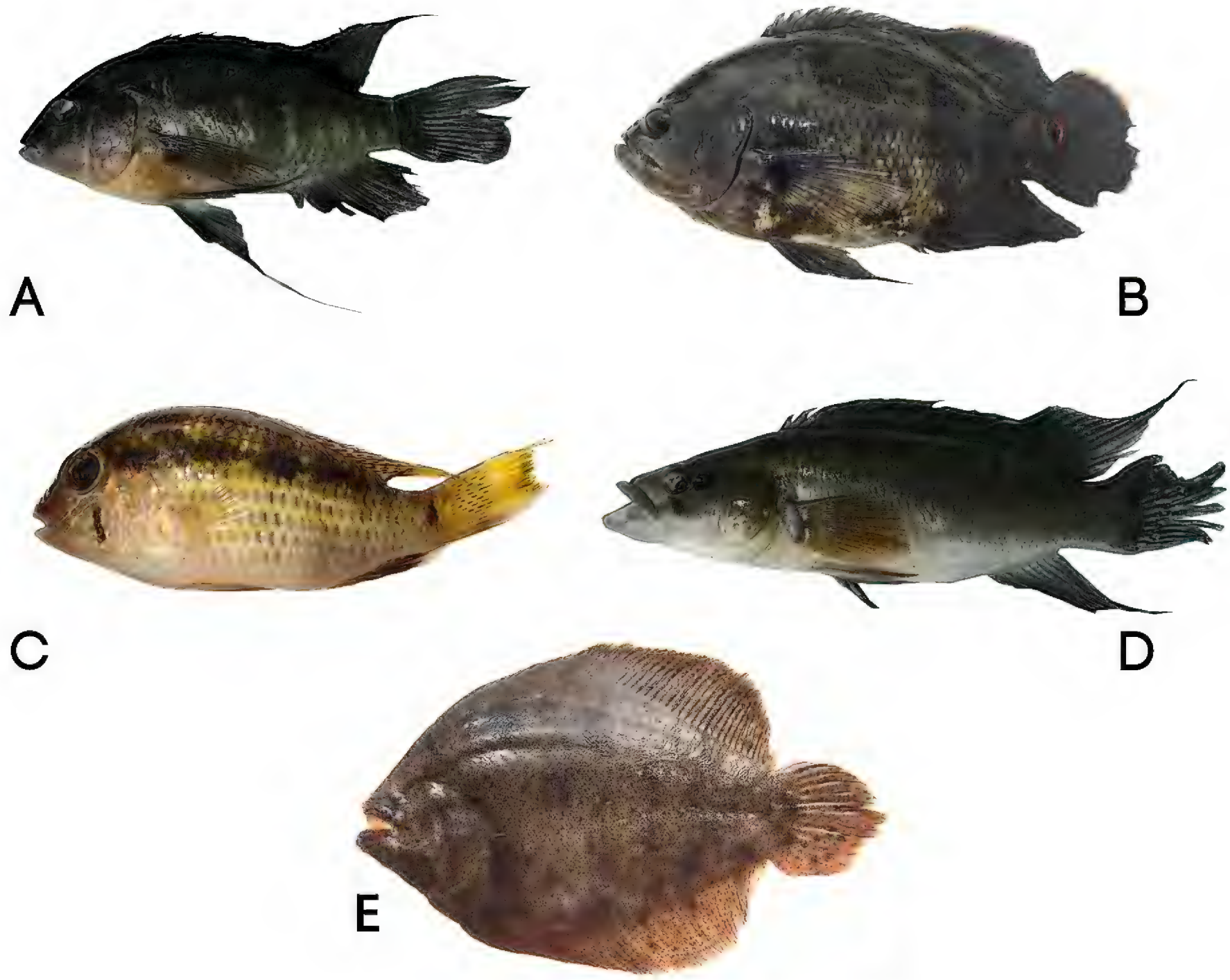


**Figure 9.** Representative freshwater fishes of the Limoncocha Lagoon, Napo river basin. **A.** *Aequidens tetramerus* (photograph by Carolina Carrillo-Moreno). **B.** *Astronotus ocellatus* (photograph by Carolina Carrillo-Moreno). **C.** *Bujurquina* sp. (photograph by Jonathan Valdiviezo-Rivera). **D.** *Crenicichla cincta* (photograph by Carolina Carrillo-Moreno). **E.** *Apionichthys menezesi* (photograph by Santiago Calero).

also important for local subsistence fishing (Valdiviezo-Rivera et al. 2012).

***Astronotus ocellatus*** (Agassiz, 1831): Figure 9B

*Lobotes ocellatus* Agassiz in Spix et al. 1831: 129—Kullander 1986: 61–70, Galvis et al. 2006: 396.
*Acara compressus* Cope 1872: 256.
*Acara hyposticta* Cope 1878: 697.

**Material examined.** Table 4.

This species has an oval, dark body. There is a vertical black ocellus, which is bordered by an orange stripe on the upper part of the caudal-fin base. This species feeds on small fish, large invertebrates, fruits, and seeds (Saul 1975). This is a popular species in subsistence fishing and is highly sought for local consumption (Valdiviezo-Rivera et al. 2012).

***Bujurquina* sp.**: Figure 9C

**Material examined.** Table 4.

This species is very similar to *Aequidens tetramerus* but it has a black longitudinal band that extends from the eye to the last ray of the dorsal fin, 6 diffuse vertical bands along the body and a teardrop-shaped band extending from the eye to the operculum (Galvis et al. 2006). *Bujurquina* spp. are omnivores, feeding on fish, aquatic and terrestrial invertebrates, plant material, algae, and detritus; they are very adaptable and their diet varies according to food availability in each season (Keenleyside 1991). They are highly valued as ornamental fish because of their attractive colors and are popular in subsistence fishing.

***Crenicichla cincta*** Regan, 1905: Figure 9D

*Crenicichla brasiliensis fasciata* Pellegrin 1904: 383.
*Crenicichla cincta* Regan 1905: 166—Kullander 1986: 44–98.

**Material examined.** Table 4.

This species has an elongated body and large protractile mouth. The head is depressed, its width and depth about equal behind the orbit (Kullander 1986). The snout is relatively long compared to other small-scaled *Crenicichla* spp. The jaw teeth are simple, conical, and a little recurved (Kullander 1986). The preoperculum is serrated, the interorbital narrower than mouth, and the caudal ocellus prominent (Kullander 1986). Scales are ctenoid; the head, chest, and median abdominal scales are

smaller than the flank scales. There are 40–43 horizontal scale series around the caudal peduncle (Kullander 1986). This species eats small fish and other invertebrates. In the breeding season, it seeks out caves in which to lay eggs (Keenleyside 1991). It is a relatively important species in commercial and subsistence fisheries (Valdiviezo-Rivera et al. 2012).

Order Pleuronectiformes
Family Achiridae

***Apionichthys menezesi*** Ramos, 2003: Figure 9E
*Apionichthys menezesi* Ramos 2003: 111.

**Material examined.** Table 4.

This species has an oval and compressed body. The eyes are conspicuous and juxtaposed, with contiguous orbits. There are 31–37 anal-fin rays and 27–30 vertebrae. Eyed side with gill opening. Scales are absent from the lips, nasal area, first rays of dorsal fin, and interradial membranes on all fins, except for narrow proximal stripe on caudal fin (Ramos 2003). Most species of *Apionichthys* feed on bottom invertebrates but occasionally they will eat other small fish. This species has no value in the commercial fishery, and although edible, it is not appreciated for subsistence fishing (Valdiviezo-Rivera et al. 2012).

A complete list of the fishes of the Limoncocha Lagoon (RBL) is presented in Table 5. Included are species reported by Walsh (2003) in an unpublished technical report. We identified 81 species from 33 families and 8 orders.

## Discussion

Thirty-three species captured in this study comprise almost 5% of the species reported by Barriga (2012) for the NP ichthyographic zone. The most abundant groups are Characiformes (21 spp., 64%), Perciformes (5 spp., 15%) and Siluriformes (3 spp., 9%). These are also the most diverse fish groups in Neotropical ecosystems and occupy many different ecological environments and niches (Lowe-McConnell 1987). Characidae, which is the most species-rich family within Characiformes (Oliveira et al. 2011, Mariguela et al. 2013), was particularly well represented in this study.

The number of species (33) gives a representativeness value of 75%. According to Urbina-Cardona et al. (2008), major or equal values to 70% are valid for infer the community snakes, while for other groups of terrestrial species it is proposed 80% (Colwell and Coddington 1995), although representativeness values have not been determined for estimating the richness of Neotropical fish.

The accumulation curve shows an increasing tendency. One hopes that with a major number of field works, an increase of the effort of sampling and manage of different fishing-tackles would extend the richness value of this lagoon. According to Murillo-Moreno et al. (2006), because the curve does not estabilize, this can be related to low population sizes, low abundance, rare species, and behavior of the organisms. Lowe-McConnell (1975) showed that freshwater habitats with no extreme fluctuation in water level, the fauna is less diverse.

One of the most heavily exploited species is *Prochilodus nigricans*, the Bocachico. *P. nigricans* is a major species in the industrial fisheries of the Amazon, comprising about 20% of the annual catch (Krause et al. 2000). In the Peruvian Amazon, Bocachicos represent 44.7% of the commercial catch landed at Iquitos (Montreuil et al. 2001).

*Anchoviella alleni* had not been previously documented from the lagoon. According to Whitehead et al. (1988) and Reis et al. (2003), the geographical distribution of this species includes the Morona and Marañón rivers; Barriga (2012) wrote that it occurs throughout the NP ichthyo-hydrographic zone. However, Barriga did not document specific locations, so our data are the first report for *A. alleni* in the Limoncocha Lagoon.

Short (SM) and medium range migratory species (MM) were collected (Zapata and Usma 2013) and included 6 characiform and one perciform species: *Leporinus friderici* (SM), *Tetragonopterus argenteus* (SM), *Curimata aspera* (SM), *Curimata vittata* (SM), *Potamorhina altamazonica* (MM), *Prochilodus nigricans* (MM), and *Plagioscion squamosissimus* (MM). These species inhabit rivers and lacustrine ecosystems, have high fertility rates, and diverse feeding habits (Barthem and Fabre 2004).

The size distribution of individuals is skewed towards smaller size classes probably because younger, smaller ones are typically more abundant than large individuals within fish species. Exploitation of fish species for human consumption may be preventing fish from attaining their maximum size.

Some Neotropical species are difficult to identify because their taxonomy is unclear. For example, Escobar et al. (2015) reported several species of *Moenkhausia*, *Aphyocharax* (Characidae), *Thoracocharax*, *Gasteropelecus* (Gasteropelecidae) and *Triportheus* (Triportheidae) from Yasuní National Park, Ecuador, have complex phylogenetic histories and potentially high cryptic diversity. Likewise, there are multiple species of *Characidium* that are not yet formally described (Da Graça and Pavanelli 2008), which makes their identification extremely difficult.

The government has not adopted fish conservation measures such as minimum catch sizes, closed fishing seasons, and regulations to limit by-catch, etc. These measures could reduce affects of fishing on the ichthyofauna of the RBL, especially for commercially important migratory species.

Our study builds on previous work by Walsh (2003), Valdiviezo-Rivera et al. (2012) and Bastidas et al. (2014) by sampling at a different time of year than previous studies, providing detailed information on the distribution of the fishes in the rivers and lagoon, and also a comprehensive list of the fishes in the RBL, adding *Astyanax*

**Table 5.** Comprehensive list of the fishes of the Limoncocha Lagoon, Napo river basin, northern Amazon region of Ecuador (including our own data and bibliographic revision).

| Species | Source |
|---|---|
| **Order Myliobatiformes** | |
| **Family Potamotrygonidae** | |
| *Potamotrygon motoro* (Müller & Henle, 1841) | Walsh (2003), Valdiviezo-Rivera et al. (2012), present study |
| *Potamotrygon scobina* (Garman, 1913) | Valdiviezo-Rivera et al. (2012) |
| **Order Clupeiformes** | |
| **Family Engraulidae** | |
| *Anchoviella alleni* (Myers, 1940) | Valdiviezo-Rivera et al. (2012), present study |
| **Order Characiformes** | |
| **Family Hemiodontidae** | |
| *Hemiodus unimaculatus* (Bloch, 1794) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Curimatidae** | |
| *Curimata aspera* (Günther, 1868) | Valdiviezo-Rivera et al. (2012), present study |
| *Curimata vittata* (Kner, 1858) | Walsh (2003), Valdiviezo-Rivera et al. (2012), present study |
| *Curimatella alburna* (Müller & Troschel, 1844) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Curimatopsis macrolepis* (Steindachner, 1876) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Potamorhina altamazonica* (Cope, 1878) | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Psectrogaster amazonica* (Eigenmann & Eigenmann, 1889) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Steindachnerina bimaculata* (Steindachner, 1876) | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| **Family Prochilodontidae** | |
| *Prochilodus nigricans* (Spix & Agassiz, 1829) | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014) |
| **Family Anostomidae** | |
| *Leporinus friderici* (Bloch, 1794) | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Schizodon fasciatus* (Spix & Agassiz, 1829) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Erythrinidae** | |
| *Hoplerythrinus unitaeniatus* (Spix & Agassiz, 1829) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Hoplias malabaricus* (Bloch, 1794) | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014) |
| **Family Lebiasinidae** | |
| *Copeina guttata* (Steindachner, 1876) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Pyrrhulina semifasciata* (Steindachner, 1876) | Valdiviezo-Rivera et al. (2012) |
| **Family Gasteropelecidae** | |
| *Carnegiella strigata* (Günther, 1864) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Thoracocharax stellatus* (Kner, 1858) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Ctenoluciidae** | |
| *Boulengerella maculata* (Valenciennes, 1850) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Acestrorhynchidae** | |
| *Acestrorhynchus lacustris* (Lütken, 1875) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Cynodontidae** | |
| *Hydrolycus* cf. *scomberoides* | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Rhaphiodon vulpinus* (Spix & Agassiz, 1829) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Serrasalmidae** | |
| *Mylossoma duriventre* (Cuvier, 1818) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Piaractus brachypomus* (Cuvier, 1818) | Valdiviezo-Rivera et al. (2012) |
| *Pygocentrus nattereri* Kner, 1858 | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Serrasalmus rhombeus* (Linnaeus, 1766) | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| **Family Characidae** | |
| *Aphyocharax* sp. | Walsh (2003), Valdiviezo-Rivera et al. (2012), present study |
| *Astyanax abramis* (Jenyns, 1842) | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Astyanax bimaculatus* (Linnaeus, 1758) | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Astyanax henseli* de Melo & Buckup, 2006 | Present study |
| *Brachychalcinus nummus* (Böhlke, 1958) | Valdiviezo-Rivera et al. (2012) |
| *Bryconamericus* sp. | Valdiviezo-Rivera et al. (2012), present study |
| *Charax tectifer* (Cope, 1870) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Chrysobrycon hesperus* (Böhlke, 1958) | Valdiviezo-Rivera et al. (2012), present study |
| *Creagrutus* sp. | Present study |
| *Ctenobrycon hauxwellianus* (Cope, 1870) | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Gymnocorymbus thayeri* (Eigenmann, 1908) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Moenkhausia dichroura* (Kner, 1858) | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Moenkhausia oligolepis* (Günther, 1864) | Valdiviezo-Rivera et al. (2012), present study |

**Table 5.** *Continued.*

| Species | Source |
|---|---|
| *Roeboides myersii* Gill, 1870 | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Tetragonopterus argenteus* Cuvier, 1816 | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| **Family Triportheidae** | |
| *Triportheus angulatus* (Spix & Agassiz, 1829) | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014) |
| *Triportheus elongatus* (Günther, 1864) | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| **Family Crenuchidae** | |
| *Characidium* sp. | Valdiviezo-Rivera et al. (2012), present study |
| **Order Siluriformes** | |
| **Family Doradidae** | |
| *Oxydoras niger* (Valenciennes, 1821) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Auchenipteridae** | |
| *Ageneiosus* sp. | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Auchenipterus nuchalis* (Spix & Agassiz, 1829) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Trachelyopterus galeatus* (Linnaeus, 1766) | Walsh (2003), Valdiviezo-Rivera et al. (2012), present study |
| **Family Pimelodidae** | |
| *Calophysus macropterus* (Lichtenstein, 1819) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Leiarius marmoratus* (Gill, 1870) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Pimelodus pictus* (Steindachner, 1877) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Heptapteridae** | |
| *Pimelodella* sp. | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Rhamdia quelen* (Quoy & Gaimard, 1824) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Callichthyidae** | |
| *Callichthys callichthys* (Linnaeus, 1758) | Valdiviezo-Rivera et al. (2012) |
| *Corydoras arcuatus* (Elwin, 1938) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Loricariidae** | |
| *Ancistrus alga* (Cope, 1872) | Valdiviezo-Rivera et al. (2012) |
| *Aphanotorulus unicolor* (Steindachner, 1908) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Farlowella platorynchus* (Retzer & Page, 1997) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Hypostomus oculeus* (Fowler, 1943) | Valdiviezo-Rivera et al. (2012) |
| *Loricaria simillima* (Regan, 1904) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Panaqolus* sp. | Valdiviezo-Rivera et al. (2012) |
| *Peckoltichthys bachi* (Boulenger, 1898) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Pterygoplichthys pardalis* (Castelnau, 1855) | Valdiviezo-Rivera et al. (2012), present study |
| *Pterygoplichthys weberi* Armbruster & Page, 2006 | Walsh (2003), Valdiviezo-Rivera et al. (2012), present study |
| *Rineloricaria* cf. *lanceolata* | Valdiviezo-Rivera et al. (2012) |
| *Sturisoma* sp. | Valdiviezo-Rivera et al. (2012) |
| **Order Gymnotiformes** | |
| **Family Sternopygidae** | |
| *Sternopygus macrurus* (Bloch & Schneider, 1801) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| **Family Gymnotidae** | |
| *Electrophorus electricus* (Linnaeus, 1766) | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Gymnotus carapo* (Linnaeus, 1758) | Valdiviezo-Rivera et al. (2012) |
| **Order Cyprinodontiformes** | |
| **Family Cynolebiidae** | |
| *Anablepsoides* cf. *limoncochae* | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Anablepsoides* cf. *urophthalmus* | Valdiviezo-Rivera et al. (2012), present study |
| **Order Perciformes** | |
| **Family Sciaenidae** | |
| *Plagioscion squamosissimus* (Heckel, 1840) | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| **Family Cichlidae** | |
| *Aequidens tetramerus* (Heckel, 1840) | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Astronotus ocellatus* (Agassiz, 1831) | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Bujurquina* sp. | Valdiviezo-Rivera et al. (2012), present study |
| *Cichla monoculus* Spix & Agassiz 1831 | Walsh (2003), Valdiviezo-Rivera et al. (2012) |
| *Crenicichla cincta* Regan, 1905 | Walsh (2003), Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014), present study |
| *Crenicichla johanna* (Heckel, 1840) | Valdiviezo-Rivera et al. (2012), Bastidas et al. (2014) |
| **Order Pleuronectiformes** | |
| **Family Achiridae** | |
| *Apionichthys menezesi* Ramos, 2003 | Valdiviezo-Rivera et al. (2012), present study |

*henseli* and *Creagrutus* sp. to the faunal list. We failed to find *Arapaima gigas*, a species that has been identified by local fishermen and park rangers (pers. com. I Cerda 2015, D Paredes 2015). It is probable that additional species can be collected with continued sampling efforts.

While there are some data on fish richness and abundance in the RBL (e.g., Walsh 2003, Valdiviezo-Rivera et al. 2012, Bastidas et al. 2014), and despite the important contributions of the present study, further research on the taxonomy, systematics, diversity, and the impacts of fishing are needed, and particularly more study on the use of fishes by local communities for food and commercialization is required.

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## Authors' Contributions

JV and CC collected the fish specimens, made the data analysis. All authors wrote and corrected the text.

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